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GEOLOGY.—*New geological formations in western Wyoming.*[1] ELIOT BLACKWELDER, Geological Survey.

As a result of the writer's field work in the Owl Creek, Shoshone, Wind River, Gros Ventre, and Teton ranges of western Wyoming, from 1910 to 1913, several new geologic formations have been recognized and the names proposed for them have been adopted by the U. S. Geological Survey. As the preparation of detailed reports on this region awaits the completion of the field studies, which have themselves been deferred for more urgent work elsewhere, several years may elapse before the reports appear in print. It therefore seems advisable to publish, in advance, definitions of these new formations, so that the names may be available for general use. In fact, while this paper was being considered and revised in manuscript, some of the names have already been used in print by other writers.[2]

### GROS VENTRE FORMATION

In Peale's[3] original description of the Threeforks (Montana) section, the Cambrian was divided into the Flathead quartzite, Flathead shale, and Gallatin limestone. Later, Hague and his associates used the same terms, but restricted the Gallatin to

[1] Published by permission of the Director of the U. S. Geological Survey.

[2] TOMLINSON, C. W., Journ. Geol. 25: 255–257. 1917. CONDIT, D. D., U. S. Geol. Survey Prof. Paper 98–O. 1916.

[3] PEALE, A. C., U. S. Geol. Survey, Bull. 110. 1893.

narrower limits. The term Flathead has now been reserved for the basal sandstone or quartzite. The use of the term Gallatin has been established in Hague's modified sense; but the present writer does not concur, because he believes Peale's original usage should have been preserved. The intervening greenish and gray calcareous shales, with gray, striped, conglomeratic and oolitic limestones, is here called the *Gros Ventre formation*. Its fossils indicate Middle Cambrian age. A typical section of the formation, exposed in the west slope of Doubletop Peak in the Gros Ventre Range, is as follows:

*Gallatin limestone (base)*

| | Feet. |
|---|---|
| Limestone; gray and ocher colored in alternate bands, contains black oolitic granules; rock massive and forms a prominent cliff in association with overlying members of the formation. Rests disconformably on underlying beds. . | 27+ |

*Gros Ventre formation*

| | |
|---|---|
| 15. Limestone; very massive, dense and gray, top eroded..... | 4+ |
| 14. Limestone; thin-bedded, gray laminated with olive drab.... | 13 |
| 13. Shale; green shale and flakes of brown-gray limestone, with a few beds of flat-pebble conglomerate and oolite. Much of this part of the section is concealed by talus ..... | 350 |
| 12. Limestone; thin-bedded, dense, hard blackish-gray rock mottled with drab and ocher, and containing some shale partings. Fragments of trilobites are rather common... | 24 |
| 11. Shale; largely green shale with thin layers of limestone like the last; largely concealed..... | 26 |
| 10. Limestone; like "12." Surfaces of beds are rough, and some of them rather massive. This forms a distinct cliff in the slope..... | 115 |
| 9. Shale; greenish clay-shale with thin plates of limestone. Largely concealed by talus..... | 36 |
| 8. Limestone; gray, with irregular laminae and pockets containing siderite (?), and therefore weathering ocher color.. | 10 |
| 7. Limestone; somewhat pisolitic, dark drab limestone weathering blue gray..... | 2½ |
| 6. Shale; gray calcareous shale and shaly limestone; largely concealed ..... | 4 |
| 5. Limestone; dark drab to bluish limestone, hard but flaggy.. | 5 |
| 4. Shale; gray calcareous shale and shaly limestone; largely concealed ..... | 6½ |
| 3. Limestone; hard but flaggy, dark gray-bluish, mottled with light ocher. Contains traces of trilobites, and forms a prominent cliff..... | 52 |

| | |
|---|---|
| 2. Limestone; buff to gray, weathering tawny brown; thin-bedded, with uneven stratification | 26 |
| 1. Shale; gray micaceous shale, largely concealed by talus from above | 95 |
| | 796 |

*Flathead Sandstone*

| | |
|---|---|
| Sandstone; with several beds of sandy shale in the upper part | about 200 |

LEIGH DOLOMITE MEMBER OF THE BIGHORN DOLOMITE

From the Teton Range eastward at least to the middle of the Wind River Mountains and north into the Absaroka Range, the massive member of the well-known Bighorn dolomite is overlain by a thin but persistent layer which deserves special recognition. In almost every section it is from 30 to 40 feet thick, and in most, if not in all, localities it is limited both above and below by disconformities. A typical section from the west slope of Dinwoody canyon, on the north side of the Wind River Range is as follows:

*Darby formation (Devonian)*

| | Feet. |
|---|---|
| 12. Basal layer a stratified breccia consisting of small bits of cream-colored dolomite and pink chert in a gray dolomite matrix. Base sharp and slightly uneven | 5.0 |

*Leigh dolomite member of Bighorn dolomite*

| | |
|---|---|
| 11. Dolomite; pale gray, finely laminated. Contains ostracods and a few small mollusks | 3.0 |
| 10. Dolomite; thin lavender-gray. Surface checkered with cracks which are stained pinkish | 5.6 |
| 9. Dolomite; thin, lavender-gray. Rather massive. Contains a few ostracods | 3.5 |
| 8. Dolomite; massive and thin. Rather brittle and full of blind joints | 5.1 |
| 7. Shale; finely laminated, pink and maroon. Calcareous | 0.3 |
| 6. Dolomite; pale gray, finely streaked and spotted with lavender. Very brittle and full of cracks | 0.9 |
| 5. Shale; calcareous, light to dark red | 0.2 |
| 4. Dolomite; like No. 3, but streaked and spotted with lavender | 4.0 |
| 3. Dolomite; like No. 2, but beds 2 to 10 inches thick | 3.5 |

2. Dolomite; dense, slabby, pale gray. Beds 1 to 4 inches thick. Sprinkled with small crinoid stems, and traces of bryozoans (?) Base not visible ..... 2.0

*Massive member of Bighorn dolomite (Ordovician)*

1. Extremely massive, cream-colored dolomite, mottled with gray in alga-like patterns.....over 100

The Leigh member differs from the rest of the Bighorn in being characterized by thin, dense and brittle, flaggy strata with smooth milk-white surfaces. It is stated verbally by Kirk and Tomlinson that, to the southwest in the Bear River Range of Utah and to the northeast in the Bighorn Range of Wyoming, the thin milk-white dolomites of the Leigh member are interbedded with the very massive rough weathering strata typical of the Bighorn. Nevertheless, it seems probable that correlations with the Leigh may be made in some districts outside of western Wyoming, where it is typically developed.

Although the dolomite generally appears to be barren of organic remains, a characteristic fauna, consisting largely of ostracods with some pelecypods and gastropods, has been found at several localities. This fauna is assigned by Ulrich and Kirk to the Richmond horizon of the late Ordovician. The member takes its name from Leigh Canyon, on the west slope of the Teton Range, for on the south side of that valley there are excellent exposures of the dolomite in its typical condition.

### DARBY FORMATION

The introduction of this new term is made necessary because none in present use fits the stratigraphy of western Wyoming. In the Threeforks section Peale gave the name Threeforks shale to the upper division of the Devonian, but included the lower dolomites, which are also Devonian, in his Jefferson limestone. Hague, Weed, and others in the Yellowstone National Park later misused the term "Threeforks" to include also the thin-bedded, dark-colored dolomite of the upper part of Peale's Jefferson, thus limiting the latter term to the very massive beds of gray dolomite below. The Darby formation is apparently equivalent to Peale's Three Forks shale plus the upper part of his

Jefferson limestone. The formation rests disconformably on the Leigh dolomite member of the Bighorn, or in some places on the massive member and is separated from the overlying Madison limestone locally, if not generally, by another eroded surface. Lithologically, it consists of a varied sequence of shales and dolomites in many colors from white to gray, green, lavender, buff, red, brown, and black. Somber colors predominate. Some of the beds are massive, others thin and brittle. Fossils are rare, but have been found in several localities. They indicate Devonian age, but permit no greater refinement in the determination. The name is derived from the canyon of Darby Creek, on the west slope of the Teton Range, where the formation is well exposed. It extends over most of northwestern Wyoming and has been recognized in modified condition as far southwest as the Wasatch Range. There are strata in the Bighorn Range[4] which resemble parts of the Darby formation, but it is not certain that they actually represent it.

A typical section of the Darby formation is exposed in the east slope of Sheep Mountain near the head of Green River.

*Madison limestone*

| | Feet. |
|---|---|
| 26. Limestone; very massive, hard, dense to crystalline; disconformity at the base indicated by irregular eroded surface and sharp contact | 44½+ |

*Darby formation*

| | |
|---|---|
| 25. Dolomite; gray, weathering brown, with deeply pitted surface; silicified corals and quartz geodes | 80 |
| 24. Shale and dolomite; interbedded buff-brown dolomite and black to gray calcareous shale; stained reddish on surfaces, and covered with *Spirophyton* markings | 22½ |
| 23. Dolomite and shale; interbedded dense gray, brown-weathering dolomite, and drab clay-shale, weathering green | 41 |
| 22. Shale; pale greenish-gray calcareous shale, with thin beds of shaly dolomite | 19 |
| 21. Dolomite and shale; light brown sandy dolomite with greenish-gray calcareous shale; ripple marks | 5½ |
| 20. Dolomite; dove-color to russet-olive, thin-bedded and shaly | 19½ |
| 19. Shale; sandy and calcareous, greenish to lavender | 5 |

[4] TOMLINSON, C. W., Journ. Geol. 25: 47–49. 1917.

| | |
|---|---|
| 18. Dolomite; dense chocolate brown | 1½ |
| 17. Shale; pale green sandy shale, with laminae of white sandstone and buff dolomite | 14½ |
| 16. Sandstone; strong cross-bedded white sandstone | ½ |
| 15. Dolomite and shale; pale drab to brownish dolomite, and calcareous shale | 18 |
| 14. Dolomite; massive gray to brown | 2 |
| 13. Shale and dolomite; gray calcareous shale, and slaty brown dolomite | 6½ |
| 12. Dolomite; massive, crystalline, sepia brown, rich in petroleum and slightly fossiliferous (Atrypa reticularis, etc.) | 11½ |
| 11. Shale; olive gray calcareous, weathering green | 4 |
| 10. Dolomite; thin bedded to massive, drab-brown, and containing geodes of jet | 16 |
| 9. Shale; sandy to calcareous drab to gray, weathering green, with thin layers of gray dolomite | 15½ |
| 8. Dolomite; dense gray argillaceous dolomite, with one layer of shaly black chert and some geodes like the last | 8½ |
| 7. Shale; drab calcareous, and associated with dolomite beds | 7 |
| 6. Dolomite; slaty, brittle, gray and brown | 30 |
| 5. Shale; black to gray, calcareous | 2 |
| 4. Dolomite; dark smoky brown to yellowish, rich in petroleum | 30 |
| 3. Dolomite; dense, brittle, finely laminated, white and lavender | 2 |
| 2. Dolomite; olive green, becoming gray above. Probably disconformable at base | 22 |
| | 428½ |

*Leigh dolomite member of Bighorn dolomite*

1. Dolomite; thin-bedded cream-colored, dense and ringing.

### DORWIN SANDSTONE MEMBER OF THE AMSDEN FORMATION

As defined by Darton, the Amsden formation included the sandstones, shales, and dolomites intervening between the Madison limestone below and the Tensleep sandstone above. Throughout western Wyoming the Amsden is divisible into two very distinct parts—an upper division of shales, sandstones, and dolomites of weak character, and a lower, massive, resistant sandstone. On account of their difference in resistance to erosion, the upper member has generally been stripped off, while the lower remains capping the mountains and ridges of Madison limestone. It therefore became advisable in practice to map the two members separately. To the lower sandstone the name

Dorwin sandstone member is given, from Dorwin Peak in the Gros Ventre Range, which is capped by this sandstone. It is separated from the underlying Madison by a distinct disconformity, but graduates into the overlying part of the Amsden. In spite of the absence of fossils, the stratigraphic position of the sandstone indicates that its age is early Pennsylvanian or late Mississippian—probably the former.

The Dorwin sandstone averages about 60 feet thick in the Gros Ventre Range, but dwindles slowly southeastward to the vicinity of Lander, where it is about 15 feet thick. Westward it has been traced in typical condition as far as Teton Pass, but has not been clearly distinguished farther southwest in Idaho. It ranges northward into Yellowstone Park, and northeastward as far as the southern part of the Bighorn Mountains. Elsewhere it is generally represented by reddish sandy shales.

### PARK CITY FORMATION

Boutwell[5] gave this name to certain Carboniferous beds in Utah. Having traced them thence, range by range, from near Park City, into central western Wyoming, the writer now desires to indicate their relation to other formations in that region and to show the lithologic variations involved. The rocks are dolomites, shales, limestones, cherts, and phosphatic beds, constituting the lower part of Darton's Embar formation, which is typically developed in the Owl Creek Range. It includes the equivalent of the Phosphoria formation, as defined by Richards and Mansfield[6] in eastern Idaho, but in addition also the upper part of their Wells formation. From the underlying Tensleep sandstone it is separated by a disconformity, but it is concordant with the overlying Dinwoody beds. Its abundant fossils belong to a somewhat unfamiliar fauna which Dr. G. H. Girty assigns to the Pennsylvanian and Permian. Although large collections have been made from the formation in the Wind River Range, they have yet received only preliminary notice in printed form,[7] and many of the species are undescribed.

[5] BOUTWELL, J. M., Journ. Geol. **15**: 437–458. 1907.
[6] RICHARDS, R. W., and MANSFIELD, G. R., U. S. Geol. Survey Bull. 577. 1914.
[7] Amer. Journ. Sci. **36**: 177–179. 1913.

A typical and centrally located section of this formation, together with the one next to be described, is exposed in the mountains at the head of the Gros Ventre River and its tributaries, especially north and east of Dorwin Peak.

*Chugwater formation*

| | Feet |
|---|---|
| 23. Shale; brick red with thin gray laminae, resting on an ill-defined and conformable bottom | 10+ |

*Dinwoody formation*

| | |
|---|---|
| 22. Shale; grayish white, with thin calcareous laminae, ripple-marks and sun-cracks | 80 |
| 21. Dolomite and shale; thin-bedded, argillaceous dolomite interbedded with gray shale and very thin quartzose flags. A few Lingulas and small pelecypods | 20 |
| 20. Shale; calcareous, olive-gray rock with thin beds of dense gray argillaceous dolomite. Some beds contain Lingulas, and others pelecypods, too poorly preserved for identification | 51 |
| 19. Flags and shale; alternating thin brittle beds of dolomite-clay-quartz rocks of pale gray color, but weathering tawny brown. Full of brownish Lingula shells | 4 |
| 18. Sandstone etc.; olive-gray calcareous sandstone, weathering smoky brown and even black, owing to presence of manganese oxides. Contain laminae and lenses of white chert, occasionally more than a foot thick | 20½ |

*Park City formation*

| | |
|---|---|
| 17. Dolomite; light gray, siliceous, with fossils appearing as silicified excrescences: *Spiriferina pulchra*, *Derbya sp.*, Fenestelloid bryozoans | 11½ |
| 16. Chert; alternating massive and shaly chert. The more massive beds have a peculiar tubular structure | 35 |
| 15. Shale and chert; black shale with thin laminae of black chert increasing toward the top | 10 |
| 14. Shale; coal black, slightly phosphatic and containing one 2-inch layer of back oolitic phosphorite | 7 |
| 13. Dolomite; black, but weathers drab. Saturated with hydrocarbons | 2½ |
| 12. Shale; black, slightly phosphatic shale | 15 |
| 11. Phosphorite; hard, black nodular bed, containing phosphatized fossils. Has a stronger odor of hydrocarbons:[3]<br>*Lingulodiscina missouriensis*<br>*Productus phosphaticus*<br>*Plagioglypta canna*<br>*Conularia sp.* | 1 |

[3] Identified by Dr. G. H. Girty.

| | | |
|---|---|---|
| 10. | Limestone; gray, petroliferous, crystalline. Filled with poorly preserved bryozoans and gastropods | 7 |
| 9. | Dolomite; gray to white, with white chert nodules | 14 |
| 8. | Sandstone; smoky gray, weathering brown. Contains angular fragments and grains of white chert, and granules of collophane | 10 |
| 7. | Chert; thin bedded and lumpy, gray to white, with greenish shale partings | 21½ |
| 6. | Shale; black, slightly phosphatic | 8 |
| 5. | Phosphorite; soft, crumbling, oolitic; passing upward into shale | 4 |
| 4. | Breccia; fragments of chert imbedded in a brown phosphatic matrix, resting on a sharp irregular surface | 2 |
| | *Tensleep sandstone* | |
| 3. | Dolomite; light gray, with nodules and laminae of gray chert | 4 |
| 2. | Sandstone; white, pitted, calcareous | 2 |
| 1. | Sandstone; creamy white, weathering light brown to pink | about 300 |

### DINWOODY FORMATION

The upper part of Darton's Embar formation consists in this region of greenish-gray shales, with many thin plates of dense, calcareous sandstone, or argillaceous dolomite, which weathers brown, tawny, and even black. This portion—which is to be distinguished from the lower or Park City portion of the Embar—is 250 feet thick at Dinwoody Creek on the north slope of the Wind River Range, but thins down to less than 50 feet near Lander. In the Owl Creek Mountains it is 75 to 100 feet thick near Anchor. Eastward, near Thermopolis, the formation becomes gypseous, and more or less reddish in color. Mr. D. Dale Condit[9] has traced it into the Bighorn Range, where it merges with the lower part of the Chugwater red-beds. Westward it becomes progressively thicker, more calcareous, and more fossiliferous, and changes by imperceptible gradations horizontally into the Woodside and Thaynes formations of southeastern Idaho. It is about 210 feet thick on Crystal Creek in the Gros Ventre Range, 350 feet thick at the north end of the Hoback Range, and thence into Idaho it rapidly increases in volume.

The Dinwoody formation is conformable both above and below. Although some beds contain abundant Lingulas and poorly pre-

[9] CONDIT, D. DALE, U. S. Geol. Survey Prof. Paper 98-O. 1916.

served pelecypods, no fossils of diagnostic value have been found in it in Wyoming. From its stratigraphic position conformably between the Park City and Chugwater formations, and from its relation to the Woodside and Thaynes formations in Idaho, which are classified as Lower Triassic, it is inferred that the Dinwoody formation is either Permian or Lower Triassic or both. The name is derived from the canyon of Dinwoody Lakes, in the Wind River Range, where the formation is completely exposed, and has been measured in detail.

BOTANY.—*Omiltemia, a new genus of Rubiaceae from Mexico.* PAUL C. STANDLEY, U. S. National Museum.[1]

From the large collections of plants obtained in Mexico a few years ago by Mr. E. W. Nelson, of the Biological Survey, many new species have already been described. A large and probably the most interesting portion of the material, however, still remains to be identified. One specimen, in particular, from the State of Guerrero has come to the writer's attention in the course of his revision of the Rubiaceae for the North American Flora. This plant, although not possessing any very unusual characters, can not be placed satisfactorily in any of the known genera of the tribe Rondeletieae, the group to which it evidently belongs. Consequently it is described here as a new genus, *Omiltemia*.

The tribe Rondeletieae is a large group, chiefly North American in distribution, many of whose genera are based upon rather slight differences. *Omiltemia* falls in the subdivision with contorted corolla lobes, and is related as closely to *Deppea* and *Lindenia* as to any genera, from both of which, however, it is distinguished by the long, exserted filaments. *Deppea*, moreover, has a short, funnelform or subrotate corolla, and *Lindenia* a very long, salverform one. In its general appearance *Omiltemia* is very unlike any of the genera of its tribe. The red tubular corolla is suggestive of *Manettia*, to which the type specimen was once referred, but that genus differs widely in its winged seeds and scandent habit.

[1] Published by permission of the Secretary of the Smithsonian Institution.

**Omiltemia** Standley, gen. nov.

Branched shrubs, more or less pubescent, the branchlets angulate. Leaves opposite and ternate, petiolate, membranaceous. Stipules minute, deciduous. Flowers of medium size, red, axillary, solitary, long-pedicellate, the pedicels bibracteolate at the base; calyx tube narrowly turbinate, the limb 4-lobate, the lobes linear-subulate, subequal, persistent; corolla tubular, glabrous, the tube elongate, slender and constricted near the base, ampliate in the upper three-fourths, the limb 4-lobate, the lobes short, oblong-ovate, subulate-acuminate, erect or ascending, contorted. Stamens 4, inserted at the base of the ampliate portion of the corolla tube; filaments filiform, exserted; anthers linear, dorsifixed, mucronate, bifid at the base. Disk depressed. Ovary 2-celled; style filiform, exserted, glabrous; stigma fusiform; ovules numerous, imbricate, the placentae oblong, peltately affixed to the septum. Capsule 2-celled, cylindric, elongate, subcoriaceous, costate, loculicidally bivalvate at the apex. Seeds numerous, minute, subglobose, obtusely angulate, the testa lustrous, reticulate; endosperm fleshy.

Type species, *Omiltemia longipes* Standley.

**Omiltemia longipes** Standley, sp. nov.

Shrub, about 3 meters high, the branches stout, grayish, terete, the branchlets slender, puberulent when young, densely leafy; stipules deltoid, about 1 mm. long; leaves mostly ternate, the petioles slender, 2–6 mm. long, puberulent, often marginate to the base, the blades oblanceolate or oblanceolate-oblong, 3–7 cm. long, 0.8–1.7 cm. wide, acuminate or long-attenuate at the base, acute to long-attenuate at the apex, often abruptly so, thin, bright-green, concolorous, glabrous above or puberulent along the costa, the venation plane, villosulous beneath along the veins or glabrate, inconspicuously striolate, the costa slender, prominent, the lateral veins prominulous, 4–6 on each side, arcuate; pedicels 1.7–3.5 cm. long, filiform, sparsely short-pilose, the bractlets minute, linear, green; calyx very sparsely short-pilose or glabrate, the tube 6–7 mm. long, the lobes 3–4 mm. long; corolla red, about 4 cm. long, the contracted portion of the tube about 1 cm. long and 1.2 mm. thick, the upper portion 5–6 mm. thick, the lobes about 5 mm. long; anthers 7 mm. long, the filaments about 2.5 cm. long; style about 4.5 cm. long; capsule 1.4 cm. long, 2.5–3 mm. thick; seeds brown.

Type in the U. S. National Herbarium, no. 399394, collected at Omilteme, Guerrero, May, 1903, *E. W. Nelson 7054*.

## ZOOLOGY.—*Opalina and the origin of the ciliate Infusoria.*[1]

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Study of a large amount of material from the United States National Museum collections of frogs and toads shows several

[1] Abridged from a paper read before the Biological Society of Washington, May 4, 1918.

dozen new species of Opalinidae and necessitates revision of the taxonomy in the family and in the Ciliata. The new forms enable us to gain a comprehensve knowledge of the plan of speciation among the Opalinidae and the conditions revealed in this family throw light upon the origin of the Ciliata.

The family Opalinidae comprises properly but two genera—*Protoopalina* (new genus) and *Opalina*. *Protoopalina* has one nucleus or in most species two nuclei. Their nuclei contain two distinct sets of large, flat, superficial chromosomes of constant and characteristic number in each species, and another more central set composed of the same number (in the species thus far studied) of slender chromosomes each consisting of a linear aggregate of granules much as in *Paramecium*, except that the granules are much coarser in these large nuclei. In mitosis the daughter nuclei each receive one-half of each chromosome of each sort (massive and granular).

*Opalina* has many nuclei (4 to several thousand). Each nucleus contains some (not many) large, flat, superficial chromatin masses of varying number in the different nuclei in the body and also numerous, more central, slender chromosomes, each a linear aggregate of granules. It is probable that these linear chromosomes are of constant number for each species, but they are too numerous for easy study. In the genus *Opalina* the granular chromosomes seem to be as carefully and regularly divided as they are in *Protoopalina*, but the larger masses of chromatin are irregularly divided in mitosis, and some of them may occasionally remain undivided, passing bodily without division into one of the daughter nuclei.

In both *Opalina* and *Protoopalina* the massive chromosomes are trophic, the granular chromosomes reproductive. Each nucleus contains both kinds of chromatin and there is no specialization, as in the higher Ciliata, of whole nuclei as trophic and other whole nuclei as reproductive.

The most characteristic feature of the higher Ciliata is the possession by each individual of a large trophic nucleus and another minute reproductive nucleus. The absence of this character in the Opalinidae justifies placing them as an archaic group, Protociliata, and classing the rest of the Ciliata as Euciliata.

The archaic features of the Protociliata are: (1) the transient character of their pleurinucleate condition, the gametes in the spring becoming uninucleate; (2) the consequent absence of differentiation of whole nuclei for trophic function (macronuclei) and of other whole nuclei for reproduction (micronuclei), each nucleus instead containing chromatin of both sorts; (3) the very primitive nature of the contractile vacuole—merely a temporary fusion of some of the axial alveoles to form an irregular and usually branched tubule opening by a posterior pore; (4) binary fission both longitudinal and transverse; (5) sexual union, the complete fusion of very dissimilar gametes. A secondary feature is the complete absence of a buccal groove. Numerous genera of Euciliata also show this secondary modification—e.g., *Hoplitophrya, Anoplophrya, Discophrya, Chromidina,* etc. In both Protociliata and Euciliata this feature is doubtless due to parasitism.

The author described mitosis in a species of *Protoopalina* (Opalina), discovered by Professor J. H. Powers, whose two nuclei are found resting in a midmitotic condition (anakhase). Awerinzew described an African species whose usually single nucleus rests in a similar midmitotic stage, and because of its uninucleate character named the species *Opalina* [*Protoopalina*] *primordialis.* In the National Musem material is a still more archaic species (as yet unnamed) from *Bufo regularis* whose single nucleus is in an earlier phase of mitosis than is that of *Protoopalina primordialis.* Starting with this unnamed species we may arrange the Opalinidae according to their nuclear condition: first a species with a single nucleus resting in a mitotic condition but little past the critical (mitotic) phase; then *Protoopalina primordialis* with nucleus in an anaphase condition; then several species with each a single nucleus in a late anaphase or a telophase condition; then numerous species each with two distinct resting nuclei; then several species each with two nuclei each of which is just entering upon mitosis; then two or more species each with two nuclei both being in about the critical phase of mitosis; then numerous species each with two nuclei both in an anaphase of mitosis; others with two nuclei each in a

telophase of mitosis. All species thus far mentioned in this paragraph are Protoopalinae with characteristic protoopalinid nuclei. Simplest in the genus *Opalina* is *O. lanceolata* (of Bezzenberger) with four nuclei; then *O. mimuta* (new species from *Bufo melanostictus*) with from five to twelve nuclei; then very many species with from one hundred to several thousand nuclei.

It seems evident that the pleurinucleate condition in the Opalinidae is due to some disturbance of the mitotic phenomena and the usual nucleus-cytoplasm relation, nuclear mitosis and body division being inhibited to a less or greater degree in different species. As this strange tendency develops we get finally bodies with a great number of nuclei. Among the Opalinids the culmination of this disturbance of the division phenomena is seen in the new species, *Opalina segmentata*, in which species even the vegetative fissions, which occur from time to time in both multinucleate and binucleate species, are inhibited after they have begun. *Opalina segmentata* is an elongated cylindrical species (snake-shaped) with thousands of nuclei. Numerous fissions which have started at different levels in the body are still incomplete, giving the whole animal a metamerized appearance. Of course this is but pseudo-metamerization for it is not due to apical budding but rather to interrupted transverse fissions which have started at different points along the elongated body.

The Opalinidae are an offshoot from the ancestral Ciliata at a time when mitotic phenomena and the nucleus-cytoplasm relation were becoming disturbed. They have some of them remained in an early stage of this condition. Others have developed the tendency further and have become highly multinucleate. The Euciliata, rising doubtless from such pseudobinucleate forms as the Protoopalinae, have passed on to a permanently binucleate condition, even their gametis being binucleate, when properly analyzed. The permanence of their binuclearity, once established, allowed the differation of one whole nucleus for nutrition (macronucleus) and of the other whole nucleus for reproduction (micronucleus). The Opalinidae as a whole are a group in which the condition of nucleus and cytoplasm as to mitosis

are still in flux. The Euciliata, advancing from this condition, have become stereotyped in a definitely binucleate state with secondary nuclear specialization.

*Classification of Ciliata*

Protociliata
- Opalinidae
  - Protoopalina
  - Opalina

Euciliata

ZOOLOGY.—*Synopsis of the supergeneric groups of Rodents.*[1] GERRIT S. MILLER, JR., and JAMES W. GIDLEY, U. S. National Museum.

Work on the taxonomy of the Rodents, living and extinct, has occupied much of our time during the past four years. This paper contains a brief synopsis of the results.

The classification which we have adopted is based on the following conception of the evolutionary course followed by the order during its development. This course has been mainly conditioned by the mechanical problem of strengthening a chewing apparatus in which the unusually important cutting function of the incisors is strongly contrasted with the grinding function of the cheekteeth; the highest degree of efficiency to be given always to the incisors and in most instances to the cheekteeth as well. The problem has been solved by five sequences of correlated changes in the masseter muscle and the bones to which this muscle is attached. All of these sequences could originate from the structures present in a generalized mammal, but there is no evidence that any rodent during its development has passed from one to another. The groups characterized by the various sequences are therefore natural. We have treated them as superfamilies: the *Sciuroidae*, *Myoidae*, *Dipodoidae*, *Bathyergoidae*, and *Hystricoidae*. Of the secondary problems the most conspicuous has been the strengthening of the cheekteeth. These teeth, however unlike their structure in extreme instances may appear, have all been developed from some primitive, low-crowned, tritubercular type not essentially different

[1] Published by permission of the Secretary of the Smithsonian Institution.

from that present in the Eocene *Paramyidae* and in living species of *Sciurus*. During the adjustment of the cheekteeth to increasingly heavy fore-and-aft grinding motion, a process which has taken place in most members of the order, the crown height has been augmented, while the original tubercles and lophs have been made more efficient by (a) increase in complexity, and (b) conversion into transverse ridges and specialized enamel plates, usually with reduction in the number of elements present. In each superfamily the characteristic modifications in the muscles and skull were begun in connection with the development of the incisors. Mechanical improvement of the cheekteeth came later. All rodent teeth have been developed from an essentially uniform original type under the influence of practically identical mechanical forces. Parallelism in highly specialized dental structures between genera and species which are not closely related is therefore frequent enough to be one of the noticeable peculiarities of the order. The history of development extends so far into the past that the essential features of structure are modernized in the oldest known Eocene rodents. No extinct member of the order has yet been found which can be regarded as ancestral to any considerable number of subsequent forms.

The order *Rodentia* may be defined as follows: Terrestrial and fossorial (occasionally arboreal or semiaquatic) placental mammals with both brain and placentation generalized in type; feet unguiculate; elbow joint always permitting free rotary motion of forearm; fibula never articulating with calcaneum; masseter muscle highly specialized, divided into three or more distinct portions having slightly different functions; cecum without spiral fold; dental formula not known to exceed i $\frac{1}{1}$, c $\frac{0}{0}$ pm $\frac{2}{1}$, m $\frac{3}{3}$ = 22 permanent teeth; incisors scalpriform, growing from persistent pulp, the enamel of the upper tooth not extending to posterior surface; distance between mandibular and maxillary toothrows approximately equal, both pairs of rows capable of partial or complete opposition at the same time, the primary motion of the lower jaw in mastication longitudinal or oblique.

## Superfamily SCIUROIDAE

Masseter lateralis superficialis with anterior head distinct, this portion of the muscle not attached to any part of the zygoma except occasionally to a point at extreme base of zygomatic plate; zygomatic plate

tilted upward, usually broad, with its superior border always above lower margin of infraorbital foramen. Infraorbital foramen inferior, transmittng nerve only; masseter lateralis passing obliquely upward to superior border of rostrum, always to exclusion of masseter medialis.

THREE-CUSPED SERIES

Teeth becoming hypsodont on the basis of a tritubercular structure.

Family SCIURIDAE

Skull never truly fossorial; infraorbital foramen with outer wall usually though not always forming a distinct canal, its orifice protected from muscular action by the presence, at or near its lower border, of an outgrowth for attachment of masseter lateralis superficialis; frontal with decurved postorbital process; cheekteeth brachydont or unilaterally hypsodont, the fundamental tritubercular plan usually (probably always) evident in functional adult teeth that have not undergone considerable wear; external form suited to arboreal or terrestrial life.

The *Sciuridae* of authors.

Subfamily *Sciurinae*.—Orbital region normal, the middle of orbit in front of middle of skull (except in genera with greatly elongated rostrum), the lachrymal bone above or in front of anterior extremity of toothrow, the zygomatic plate not especially emarginate below, the postorbital process indicating an evident boundary between orbit and temporal fossa; no parachute membrane.

The entire family except the members of the two following groups; Oligocene to Recent; Northern Hemisphere, South America, continental Africa.

Subfamily *Nannosciurinae*.—Like the *Sciurinae* but orbital region abnormal, the middle of orbit behind middle of skull (rostrum short), the lachrymal bone above middle of toothrow, the zygomatic plate conspicuously emarginate below, the postorbital process not indicating an evident boundary between large orbit and much reduced temporal fossa.

*Nannosciurus* of the Malay region, *Myosciurus* of West Africa, and *Sciurillus* of South America (the last not seen); Recent.

Subfamily *Pteromyinae*.—Like the *Sciurinae* but with a well developed parachute membrane present.

The Flying-squirrels; Middle Miocene to Recent; Northern Hemisphere.

Family GEOMYIDAE

Skull fossorial; zygoma robust; infraorbital foramen always at end of a long canal, its orifice protected from muscle pressure by counter-

sinking in an oblique sulcus; frontal without postorbital process; cheek-teeth evenly hypsodont or in their extreme development ever-growing, the fundamental tritubercular plan lost in functional adult teeth, the first and second molars of adult consisting of either one or two simple loops. External form in living members of the group highly modified for underground life.

Subfamily *Entoptychinae.*—Angular portion of mandible mostly below alveolar level; cheekteeth rooted, the enamel pattern of first and second molars consisting of two simple loops joined at protomere.[2]

*Entoptychus;* North American Oligocene.

Subfamily *Geomyinae.*—Angular portion of mandible mostly above alveolar level; cheekteeth ever-growing, the first and second adult molar consisting each of a simple prism, with an enamel plate always present on anterior surface in upper teeth and on posterior surface of lower teeth.

North American pocket gophers; Miocene to Recent.

### Family Heteromyidae

Essential characters as in the *Geomyidae* but skull not fossorial; zygoma slender; orifice of infraorbital canal protected from muscle pressure by countersinking in a vacuity which extends transversely through rostrum; external form murine or saltatorial.

North American pocket-mice and kangaroo-rats; Middle Oligocene (*Heliscomys*) to Recent.

#### FOUR-CUSPED SERIES

Teeth becoming hypsodont on the basis of a quadritubercular structure.

### Family Adjidaumidae

Zygomasseteric structure[3] and infraorbital canal as in the *Sciuridae;* cheekteeth $\frac{4}{4}$, slightly hypsodont, the enamel pattern unmodified heptamerous.[4]

*Adjidaumo;* North American Middle Oligocene.

[2] Protomere = inner side of maxillary cheekteeth and outer side of mandibular cheekteeth.

Paramere = outer side of maxillary cheekteeth and inner side of mandibular cheekteeth.

[3] Zygomasseteric structure = the combined and correlated structures of the masseter muscle and of the skull in the region at which the muscle takes its origin.

[4] Heptamerous pattern = the enamel pattern of a flat-crowned cheektooth in which each of seven original tubercles is represented by a loop (two on the protomere, five on the paramere).

### Family EUTYPOMYIDAE

Like the *Adjidaumidae* but with cheekteeth somewhat more hypsodont and the heptamerous enamel pattern complicated by the development of a considerable number of secondary closed loops which appear in partially worn teeth as an aggregation of minute enamel lakes covering nearly entire surface of crown.

*Eutypomys;* North American Middle Oligocene.

### Family CHALICOMYIDAE

Like the *Adjidaumidae* but cheekteeth strongly hypsodont and enamel pattern reduced-heptamerous (sometimes paralleling that of the *Hystricidae*) becoming rapidly simplified as the crowns wear away; skull occasionally fossorial; no postorbital process on frontal; no pit-like depression in basioccipital region.

*Chalicomys* (= *Steneofiber*) and related genera, European Miocene and Pliocene; *Trogontherium*, European Pliocene and Pleistocene; *Palaeocastor*, *Eucastor* and related genera, North American Upper Oligocene and Lower Pliocene.

### Family CASTORIDAE

Skull with rostrum broadened and deepened and braincase narrowed; basioccipital region with conspicuous pit-like depression; cheekteeth not ever-growing but so excessively hypsodont that the slightly reduced-heptamerous pattern (parallel: *Myocastor*) changes little with age and rarely if ever wears out; external form highy modified for aquatic life; caudal vertebrae flattened.

*Castor;* Lower Pliocene to Recent; Northern Hemisphere.

### Family CASTOROIDIDAE

Zygomasseteric structure modified by the passage of the shaft of the incisor below the infraorbital foramen instead of above it, the ridge formed by the tooth dividing the area of masseteric origin on side of rostrum into two planes; posterior nares divided horizontally by the median fusing of palatine bones over roots of cheekteeth; teeth ever-growing, the enamel pattern a series of 5–7 parallel transverse ridges (parallel: *Dinomyidae*).

*Castoroides;* North American Pleistocene.

## Superfamily MUROIDAE

Zygomasseteric structure as in the *Sciuroidae* except: Infraorbital foramen superior in whole or in part, entered or traversed by muscle as well as nerve; masseter lateralis seldom reaching superior border of rostrum, and never doing this to exclusion of masseter medialis.

#### THREE-CUSPED SERIES

Modifications of teeth based on an underlying tritubercular structure.

### Family Muscardinidae

Skull with no striking modifications of general form; zygomatic root much as in the *Sciuridae* except that its anterior face is nearly vertical instead of strongly oblique, and the infraorbital foramen extends above median level of orbit, receiving or transmitting a strand of muscle as well as the nerve; no postorbital processes; auditory bullae large, globular, rounded in front; cheekteeth $\frac{4}{4}$, brachydont (in *Leithia* subhypsodont), the enamel pattern reduced-hexamerous in forms with basin-shaped crowns, passing to a system of parellel transverse ridges in those with flat crowns (parallel: *Graphiuridae*); external form showing a combination of murine and sciurine features.

*Eliomys, Dyromys, Glis, Muscardinus, Leithia;* Old World Middle Miocene to Recent.

#### FOUR-CUSPED SERIES

Modifications of teeth based on an underlying quadritubercular structure.

### Family Ischyromyidae

General characters of the skull as in the *Muscardinidae;* teeth $\frac{4}{4}$, moderately hypsodont, rooted, the fundamental structure quadritubercular, the enamel pattern in worn teeth reduced-heptamerous.

*Ischyromys;* North American Middle Oligocene.

### Family Cricetidae

Fundamental zygomasseteric structure as in the *Muscardinidae* and *Ischyromyidae,* but infraorbital foramen usually enlarged and specialized, consisting of a rounded upper portion for transmission of muscle and a narrow lower portion for transmission of nerve, the zygomatic root developed into a broad, oblique plate; skull varying excessively in form, but always without postorbital process on the frontal; check-teeth $\frac{3}{3}$, the crown structure showing all stages from brachydont to ever-growing, the fundamental structure quadritubercular, the enamel pattern varying from simple heptamerism to excessive specialization, the tubercles in the maxillary teeth always presenting a longitudinally biserial arrangement and never developing a functional third series on lingual side of crown; external form murine or fossorial.

Subfamily *Cricetinae.*—Skull without special modification, the zygomasseteric structure as usual in the family, the squamosal not developing a postorbital ridge or process; molars rooted, their crowns varying gradually from tubercular and brachydont to flat-crowned and strongly hypsodont, when in the latter condition the prisms not opposite (compare *Gerbillinae*) and the posterior termination of $m^1$ and $m^2$ not angular (compare *Microtinae*).

The *Cricetinae, Sigmodontinae, Neotominae,* and *Nesomyinae* of authors; Oligocene to Recent; continental region of the world; Madagascar.

Subfamily *Gerbillinae.*—Auditory bullae and entire posterior portion of skull enlarged; teeth subhypsodont or hypsodont, flat-crowned in adults, with opposite prisms, these tending to form transverse ridges joined at median line, or, in their extreme development, to separate into plates; external form saltatorial.

The *Gerbillinae* of authors; Recent only, unless *Trilophomys* from the Pliocene of France is a member of the group; Asia and Africa.

Subfamily *Microtinae.*—Like the more hypsodont members of the subfamily *Cricetinae* but cheekteeth often growing from a persistent pulp, the enamel pattern always consisting of (at least partially) alternating triangles, the posterior termination of $m^1$ and $m^2$ never rounded; squamosal with distinct postorbital ridge or process.

The *Microtinae* of authors; Miocene to Recent; Northern Hemisphere.

Subfamily *Lophiomyinae.*—Like the *Cricetinae* with tubercular, slightly hypsodont teeth, but skull with temporal fossa bridged by a plate formed of laminae arising from the jugal, frontal, and parietal, a structure not known to occur elsewhere among rodents.

*Lophiomys;* Recent; Africa.

### Family Platacanthomyidae

Like the *Cricetidae* but zygomasseteric structure unusual, the infraorbital foramen of normal cricetine form, but zygomatic plate much narrowed, and masseter lateralis profundus extending its line of attachment along upper zygomatic border to side of rostrum above foramen; cheekteeth subhypsodont, the enamel pattern a modified heptamerous with tendency to form parallel oblique cross-ridges (parallel: *Muscardinidae*).

*Platacanthomys* and *Typhlomys;* Recent; Southern Asia.

### Family Rhizomyidae

Like the *Cricetidae* but zygomasseteric structure unusual, the infraorbital foramen with neural portion reduced or obliterated by partial or entire fusion of zygomatic plate with side of rostrum; skull and external form fossorial.

Subfamily *Tachyoryctinae.*—Infraorbital foramen with neural portion reduced to an inconspicuous notch by fusion of the broad zygomatic plate with side of rostrum (outline of plate below foramen usually visible); skull strongly fossorial; cheekteeth closed at base but extremely hypsodont, the enamel pattern not changing in character during adult life; enamel pattern in adult consisting of 2–3 parallel curved cross-ridges (the concave surface directed backward and outward in upper teeth, forward and inward in lower teeth; parallel: *Protechimys*); reduced-heptamerism evident in unworn enamel cap; external form modified, though not excessively, for underground life.

*Tachyoryctes;* Recent; Africa.

Subfamily *Rhizomyinae.*—Like the *Tachyoryctinae* but peculiarities of infraorbital region carried farther, the neural notch being obliterated and the foramen appearing as a small orifice confined to upper surface of zygomatic root; teeth moderately hypsodont, the enamel pattern obviously heptamerous or reduced-heptamerous and changing rapidly during adult life.

*Rhizomys* and related genera; Pliocene to Recent; southern Asia.

Subfamily *Braminae.*—Like the *Rhizomyinae* but cheekteeth with definitely prismatic structure.

*Bramus;* Pleistocene; northern Africa (not seen).

## Family Spalacidae

Like the *Cricetidae* but zygomasseteric structure unusual, the zygomatic plate narrowed and turned downward to a nearly horizontal position, thus doing away with the separate neural portion of the opening by a process the exact opposite to that bringing about a similar result in some of the *Rhizomyidae;* skull excessively fossorial, the lambdoid crest carried forward to level of zygomatic root.

Subfamiy *Myospalacinae.*—Mandible scarcely movable at symphysis, a large post-symphyseal buttress early developed; cheekteeth growing from persistent pulps, the crowns elongated, the enamel pattern consisting of alternating triangles, the posterior termination of $m^1$ and $m^1$ rounded.

*Myospalax;* Recent; Asia.

Subfamily *Spalacinae.*—Mandible movable at symphysis throughout life; cheekteeth moderately hypsodont, rooted, subterete, the pattern reduced-heptamerous, changing rapidly with wear; skull with the characters of the family carried to such an extreme as to make it the most fossorial type known among rodents.

*Spalax,* Recent, *Prospalax,* Upper Pliocene, and an undescribed genus from the upper Oligocene; eastern Mediterranean Region, and southern Europe.

## Family Muridae

Skull as in the typical *Cricetidae;* cheekteeth $\frac{3}{3}$, the upper teeth with a functional row of tubercles on lingual side of crown internal to the protocone and hypocone, these tubercles entering conspicuously into the plan of modification of the crowns.

Subfamily *Dendromyinae.*—Upper cheekteeth with triserial arrangement not fully developed; manus with only 3 functional digits.

The *Dendromyinae* of authors; Recent; Africa.

Subfamily *Murinae.*—Upper cheekteeth with fully developed triserial arrangement of tubercles always evident, though frequently vary-

ing from the symmetrical plan; crowns brachydont or slightly hypsodont; manus normal.

The *Murinae* of authors; Upper Miocene to Recent; Old World, except Madagascar.

Subfamily *Phloeomyinae*.—Upper cheekteeth with triserial arrangement of elements obscured by flattening out of each trio of tubercles to form a simple, detached, transverse lamina (parallel: *Diplomys*); crowns moderately hypsodont; braincase relatively small and auditory bullae reduced; external form heavy, arboreal.

*Phloeomys*; Recent; Philippine Islands.

Subfamily *Otomyinae*.—Upper cheekteeth with same modification as in the *Phloeomyinae*, but $m^3$ tending to become the dominant tooth in the series, its size always greater than that of $m^3$, and its elements usually reduplicated; external form heavy, terrestrial.

*Otomys*; Recent; Africa.

Subfamily *Hydromyinae*.—Upper cheekteeth with triserial arrangement obscured by suppression of tubercles of outer series; $m^3$ vestigial.

The *Hydromyinae* of authors; Recent; Australian Region.

## Superfamily DIPODOIDAE

Masseter lateralis superficialis with anterior head not distinct, this portion of the muscle attaching along a considerable area on anterior border of zygoma; zygomatic plate nearly horizontal, always narrow and completely beneath infraorbital foramen. Angular portion of mandible not distorted outward at base to permit free passage of a branch of the masseter lateralis, its general direction not parallel with zygoma.

### THREE-CUSPED SERIES

Modifications of teeth based on an underlying tritubercular structure, the hypocone when present not entering into the essential mechanical scheme of the crown.

A.—*Skull with no special pecularities except that the auditory bullae appear to be imperfect or absent (perhaps merely reduced as in* Phloeomys*); infraorbital foramen not transmitting muscle; cheekteeth brachydont or subhyposodont, their structure essentially as in the less modified Sciuridae.*

### Family PARAMYIDAE

Rostrum and braincase approximately equal in width, infraorbital foramen very small, not visible in lateral view of the skull; cheekteeth $\frac{6}{6}$, the upper molars obviously and simply tritubercular in general plan, the hypocone, when present, appearing as a supplement to the original structure of the tooth.

*Paramys, Mysops, Prosciurus,* and related genera; North American Lower Eocene to Middle Oligocene.

B.—*Skull and teeth as in the Paramyids except that the auditory bullae are well developed, the infraorbital foramen is enlarged to transmit a small strand of muscle, and the cheekteeth are flattened.*

Family GRAPHIURIDAE

Cheekteeth $\frac{4}{4}$, brachydont, crowns wider than long, basin-shaped with small tubercles and low ridges (parallel: *Muscardinidae*); skull with no special peculiarities, the braincase much wider than rostrum; auditory bullae globular; external form muscardinine.

*Graphiurus*; Recent; Africa.

C.—*Skull fossorial (except perhaps in the Allomyidae); infraorbital foramen not transmitting muscle; auditory bullae well-developed; cheekteeth brachydont, hypsodont, or ever-growing; modification of crowns based on a structure including well developed protoconule and metaconule, and conspicuously trenchant outer commissures.*

Family ALLOMYIDAE

Cheekteeth $\frac{5}{4}$, brachydont or moderately hypsodont, the tritubercular structure of upper teeth evident in unworn crowns; protoconule and metaconule large; functional cusps in $m^1$ and $m^2$; mesostyle appearing in hypsodont forms as a conspicuous median rib on outer surface of crown (parallel: *Pseudosciuridae*).

*Allomys, Haplomys,*[5] *Meniscomys, Mylagaulodon;* North American Upper Oligocene and Miocene.

Family APLODONTIIDAE

Like the *Allomyidae* but the skull greatly widened posteriorly, the auditory bullae flask-shaped with neck directed horizontally outward; cheekteeth growing from persistent pulp, the unworn caps showing evident pattern of the *Allomys*-type, this soon wearing away and leaving a simple enamel ring; paramere with conspicuous vertical ridge.

*Aplodontia*; Pleistocene and Recent; *Liodontia,*[6] Miocene; western North America.

Family CYLINDRODONTIDAE

Skull fossorial with braincase slightly wider than rostrum; cheekteeth $\frac{4}{4}$, subterete, excessively hypsodont but not growing from persistent pulp, the enamel pattern in considerably worn upper teeth consisting of an outer ring and a central lake.

*Cylindrodon;* North American Lower Oligocene. Position of group doubtful.

[5] New genus, type *Meniscomys liolophus* Cope.

[6] New genus, type *Aplodontia alexandrae* Furlong.

FOUR-CUSPED SERIES

Modifications of teeth based on an underlying quadritubercular structure, the hypocone always entering into the essential mechanical scheme of the crown.

A.—*Skull not specially modified; upper molars with large protoconule and metaconule, and conspicuously trenchant outer commissures, their structure paralleling that of the Allomyidae in the three-cusped series.*

Family PSEUDOSCIURIDAE

Skull essentially as in the *Sciuravidae* but with larger infraorbital foramen which may have transmitted a strand of muscle.

*Pseudosciurus;* European Oligocene.

B.—*Skull excessively fossorial; occipital region obliquely truncate, with lambdoid crest moved forward nearly to level of zygomatic root; frontal with short postorbital process; bony horn-cores present on rostrum in two genera, absent in a third; cheekteeth highly modified from a normal heptamerous structure, the grinding function of toothrow in adult almost completely taken over by the greatly enlarged fourth premolar.*

Family MYLAGAULIDAE

General structure of skull much as in the *Aplodontiidae;* cheekteeth $\frac{4}{4}$ or $\frac{3}{3}$; a reduced-heptamerous pattern evident in slightly worn crowns, but this giving place with wear to a system of narrow longitudinal and oblique lakes; molars relatively small, soon crowded out by the premolar, an excessively hypsodont, laterally compressed tooth, closed at the base, and rapidly increasing in crown length from the unworn surface downward. Skeleton highly modified for underground life.

*Mylagaulus, Ceratogaulus,* and *Epigaulus;* North American Miocene and Pliocene.

C.—*Skull without special peculiarities; infraorbital foramen moderate or very large, transmitting both muscle and nerve; cheekteeth subhypsodont or brachydont, their modifications based on a heptamerous structure in which the ridges are narrow and the reentrant spaces wide (parallels:* Funisciurus, *Erethizontidae); external form glirine or pteromyine; under side of tail with scaly outgrowths near base.*

Family ANOMALURIDAE

Skull with moderate infraorbital foramen; lower zygomatic root at level immediately in front of anterior cheektooth; anterior point of masseteric insertion on mandible beneath hinder part of $m_1$; no discrepancy between size of incisors and molars; cheekteeth subhypsodont, their crowns flat, longer than wide; external form pteromyine.

*Anomalurus;* Recent; Africa.

### Family IDIURIDAE

Like the *Anomaluridae* but skull with infraorbital foramen greatly enlarged, the lower zygomatic root nearer to incisor than to anterior cheektooth; anterior point of masseteric insertion on mandible in front of $pm^4$; incisors excessively heavy; cheekteeth weak, extremely brachydont, their crowns flat, wider than long.

Subfamily *Idiurinae.*—Flying membrane present; cheekteeth with two complete median transverse ridges.
*Idiurus;* Recent; Africa.

Subfamily *Zenkerellinae*—Flying-membrane absent; cheekteeth with one complete median transverse ridge.
*Zenkerella;* Recent; Africa.

D.—*Skull without striking peculiarities other than a tendency to assume a form characterized by broad braincase, large auditory parts, and weak rostrum (parallels; Gerbillinae, Octodontinae); infraorbital foramen transmitting muscle in all members of the group in which the skull is known except probably* Sciuravus; *cheekteeth varying from brachydont to evergrowing, their modifications based on a heptamerous structure in which the ridges are wide and the reentrant spaces narrow.*

### Family SCIURAVIDAE

Infraorbital foramen small, but visible in lateral view of skull, probably transmitting nerve only; cheekteeth $\frac{4}{4}$, brachydont; the structure of the upper molars obviously and simply quadritubercular.
*Sciuravus;* North American Middle Eocene.

### Family ZAPODIDAE

Infraorbital foramen large, transmitting muscle as well as nerve; cheekteeth varying in number from $\frac{5}{4}$ in the earlier members of the group to $\frac{3}{3}$ in the most advanced; the quadritubercular crown structure usually though not always much modified; metatarsals not reduced or fused.

Subfamily *Theridomyinae.*—The earlier, less modified members of the family: $pm^4$ a large, functional tooth; crowns of cheekteeth varying from brachydont and simply quadritubercular (*Sciuroides*) to hypsodont and much reduced heptamerous (*Issiodoromys;* parallel: *Eocardia*).
The *Theridomyidae* of authors; European Lower Eocene to Miocene.

Subfamily *Sicistinae.*—Cheekteeth brachydont, $\frac{3}{3}$, distinctly quadrituberculate, the enamel of moderately worn upper molars with a simple heptamerous pattern; external form murine, the hind legs and feet not lengthened.
*Sicista,* Recent, Eurasia; *? Eomys,* European Upper Eocene.

Subfamily *Zapodinae.*—Cheekteeth subhypsodont, $\frac{4}{4}$ or $\frac{3}{3}$, flat crowned, the enamel pattern of the upper molars heptamerous, slightly or considerably modified; external form saltatorial, the hind legs and feet lengthened.

*Eozapus*, Recent, China; *Zapus*, *Napaeozapus*, Pleistocene and Recent, North America.

### Family Dipodidae

Like the *Zapodidae* but with the inner and outer metatarsals reduced or absent and the three median fused to form a canon bone; cheekteeth hypsodont, the heptamerous enamel pattern undergoing modifications most of which are parallel to those taking place in the teeth of the *Cricetidae* and in the hystricine families.

Subfamily *Protoptychinae.*—Upper cheekteeth 4, moderately hypsodont; $pm^4$ a large, functional tooth; skull with relatively broad rostrum and narrow braincase.

*Protoptychus;*[7] North American Upper Eocene.

Subfamily *Dipodinae.*—Cheekteeth $\frac{4}{4}$ or $\frac{3}{3}$, strongly hypsodont; $pm^4$ vestigial; skull with relatively narrow rostrum and broad braincase.

The *Dipodidae* of authors who recognize the *Zapodidae* as a distinct family; Pleistocene and Recent; Eurasia and northern Africa.

### Family Ctenodactylidae

Cheekteeth growing from a persistent pulp, the adult pattern reduced to a simple ring infolded on one or both sides (parallel: *Octodontinae*); external form fossorial.

*Ctenodactylus* and related genera from the Mediterranean region; Pliocene to Recent.

### Family Pedetidae

Cheekteeth subterete, growing from a persistent pulp; all trace of the original crown structure lost, the unworn enamel cap transversely cleft, the adult pattern consisting of a narrow median infold from the paramere extending nearly across to opposite side; external form conspicuously saltatorial, but median metatarsals showing no tendency to become reduced or fused.

*Pedetes;* Recent; Africa.

## Superfamily BATHYERGOIDAE

Zygomasseteric structure as in the *Dipodoidae* except: Angular portion of mandible distorted outward to allow passage of a specialized and

[7] While *Protoptychus* is a true dipodid with few primitive characters its exact position is not clear. It may prove to be a member of the *Theridomyinae*; but for the present we prefer to place it in the *Dipodidae* on account of its resemblance to the recent genus *Euchoreutes*.

enlarged distal anterior limb of the masseter lateralis superficialis, its general direction parallel with zygoma. Masseter medialis arising from upper margin of orbit and not passing through small infraorbital foramen.

### Family BATHYERGIDAE

Skull and external form with conspicuous fossorial adaptations. Cheekteeth extremely hypsodont, though not ever-growing; enamel pattern in adult a ring with or without a reentrant fold on one or each side (parallel: *Octodontinae*); number of cheekteeth ranging from $\frac{2}{2}$ to $\frac{1}{1}$. (In the genus, *Heliophobius*, with the greatest number of teeth there are never more than $\frac{2}{1}$ functional at one time; the apparent addition of one tooth in the upper jaw and two in the lower jaw to the maximum rodent formula is probably due to a specialized condition of the milk dentition.)

The *Bathyergidae* of authors; Recent; Africa.

## Superfamily HYSTRICOIDAE

Zygomasseteric structure as in the *Bathyergoidae* except: Masseter medialis arising from side of rostrum and passing through large infraorbital foramen.

#### LATERALIS SERIES

Masseter lateralis the chief agent in modifying form of outer side of mandible; an oblique ridge extending forward from lower border of angular process usually present for attachment of this muscle.

A.—*Lachrymal bone small, forming no important part of zygomatic root, its lower portion confined within orbit; lachyrmal canal closed in front of orbit.*

### Family HYSTRICIDAE

Skull with no special peculiarities other than a tendency (most pronounced in the genus *Hystrix*) to inflation of the rostral and frontal regions; mandibular rami rather freely movable at symphysis; angular process deep, neither produced backward conspicuously behind articular level nor folded inward along lower margin; cheekteeth $\frac{4}{4}$, their enamel pattern slightly removed from the simple heptamerous type, the reentrant folds narrow and not angular.

Old World porcupines; Upper Miocene to Recent.

Subfamily *Hystricinae*.—Base of upper zygomatic root over a point decidedly behind the anterior extremity of toothrow; cheekteeth strongly hypsodont, closed at base but without definite roots; sacral vertebrae 4.

*Hystrix, Acanthion, Thecurus;* Africa, southern Asia, and Malay region.

Subfamily *Atherurinae.*—Base of upper zygomatic root over anterior extremity of toothrow; cheekteeth subhypsodont, with well developed roots; sacral vertebrae 3.

*Atherurus, Trichys;* Recent; Malay region.

## Family ERETHIZONTIDAE

Like the *Hystricidae* but: Mandibular rami with conspicuous postsymphyseal buttresses which prevent movement at the symphysis; lower border of angular process folded inward; cheekteeth subhypsodont, flat crowned, with reduced-heptamerous enamel pattern characterized by narrow ridges and wide reentrant spaces, the spaces on the paramere tending to become transformed into pits (parallels: *Funisciurus, Anomaluridae*). Upper zygomatic root over anterior part of toothrow; feet noticeably modified for arboreal life.

New World porcupines except *Chaetomys:* Oligocene to Recent. Oligocene of Egypt?[8] Extinct South American genera: *Asteromys, Eosteiromys, Parasteiromys, Steiromys.*

## Family ECHIMYIDAE

Like the *Erethizontidae* but lower border of angular process usually with no evident infolding, feet usually not modified for arboreal life, and adult cheekteeth with narrow reentrant folds; cheekteeth varying from brachydont to ever-growing, the structure when hypsodont not multilaminar.

Subfamily *Echimyinae.*—Fossorial specialization usually absent; skull and cheekteeth showing great variety of form; enamel pattern not simplified to a ring with an infold on one or each side.

Tropical America; Miocene to Recent. Spiny-rats (provisionally including *Chaetomys*), Hutias (*Capromys, Plagiodontia*), etc.; also many extinct genera, among them *Acaremys, Boromys, Brotomys, Colpostemma, Eocardia* (parallel: *Issiodoromys*), *Eoctodon, Graphimys, Gyrignophus, Haplostropha, Heteropsomys, Homopsomys, Isolobodon, Prospaniomys, Protadelphomys, Protacaremys, Sciamys, Scleromys, Spaniomys, Stichomys, Strophostephanus, Tribodon.* It is probable that this group needs subdividing.

Subfamily *Octodontinae.*—Fossorial specialization usually present; cheekteeth, except in earliest known genera, with enamel pattern completely simplified to a ring with an infold on one or each side (parallel: *Ctenodactylidae*).

South America; Oligocene to Recent. Recent genera: *Ctenomys, Octodon, Octodontomys, Spalacopus.* Among the fossil genera are: *Cephalomys, Dicoelophorus, Eucoelophorus, Litodontomys, Neophanomys, Palaeoctodon, Phtoramys, Pithanotomys, Plataeomys, Scotomys.*

[8] The genera *Phiomys* and *Metaphiomys*, based on lower jaws and teeth, have no characters by which they can at present be referred to any other family.

### Family Petromyidae

In general resembling the *Octodontinae* but crown of each cheektooth margined by two elevations on the protomere, these elevations probably resulting from the unusual obliquity at which the teeth appear to be set. The teeth are rooted, strongly hypsodont; the enamel pattern consists of two transverse lobes united by a median isthmus, the outer edges of the lobes becoming joined in the upper teeth when worn. No specimens examined.[9] Recognized as a family by Tullberg, partly on whose authority we continue to treat it as distinct. The characters of the teeth indicate important mechanical peculiarities of the chewing apparatus. The enamel pattern appears to be of a type which could be directly derived from that present in the relatively low-crowned molars of *Erethizon* and the Oligocene African *Phiomys*.

*Petromys*, South Africa: Recent.

### Family Myocastoridae

In general like the *Erethizontidae* but upper zygomatic root over middle of toothrow, and cheekteeth with structure paralleling that present in *Castor;* lateral process of paroccipital large, projecting freely above base of greatly elongated paroccipital process; in living species external form modified for aquatic life.

*Myocastor* and related fossil genera; South America; Miocene to Recent.

### Family Thryonomyidae

Like the *Myocastoridae* but cheekteeth with structure paralleling that present in some of the *Echimyinae*, and lateral process of paroccipital small, closely applied to base of moderately large paroccipital process; external form not modified for aquatic life.

*Thryonomys;* Africa; Recent.

### Family Dinomyidae

Like the *Echimyidae* but cheekteeth combining a multilaminar structure with excessive hyposodonty (parallel: *Castoroides*); so far as known the external form is robust, terrestrial.

South America and the Greater Antilles; Miocene to Recent. Includes the living *Dinomys* and the extinct genera *Amblyrhiza, Briaromys, Discolomys, Elasmodontomys, Gyriabrus, Megamys, Neoepiblema, Olenopsis, Potamarchus, Tetrastylus.*

### Family Cuniculidae

Not essentially different from the *Dinomyidae*, but the jugal and part of the maxillary are expanded to form a conspicuous cheekplate, the surface of this becoming excessively rugose in adult; cheekteeth strongly

[9] Mr. Oldfield Thomas has kindly sent us photographs of a skull in the British Museum (No. 4.2.3.98).

hypsodont, but enamel structure not completely multilaminar; external form robust, terrestrial.

*Cuniculus* (="*Coelogenys*"); Tropical America; Pleistocene and Recent.

### Family Heptaxodontidae

First tooth of maxillary series mechanically dominant, cheekteeth apparently reduced to $\frac{3}{3}$, conditions not known elsewhere in the *Hystricoidae*, and indicating zygomasseteric development along a line different from that followed elsewhere in the group; enamel structure multilaminar with reduplication in the anterior tooth; diagnostic cranial characters unknown.

*Heptaxodon;* Porto Rico; Pleistocene? The genus *Morenia* from the South American Miocene may be a second member of the family; it is at present known from isolated teeth only.

B.—*Lachrymal bone large, usually forming an important part of zygomatic root, its lower portion extending forward out of orbit to a level in front of anterior margin of infraorbital foramen; some part of lachrymal canal open on side of rostrum in front of orbit.*

### Family Dasyproctidae

Skull generalized in structure, closely resembling that of the less specialized *Hystricidae;* cheekteeth hypsodont but with a nearly unmodified heptamerous structure, paralleling that in the *Hystricidae;* external form cursorial, the legs lengthened, the digits 5–3.[10]

The *Dasyproctidae* of authors with *Cuniculus* removed and *Neoreomys* added; South and Middle America; Miocene to Recent.

### Family Chinchillidae

Cheekteeth with heptamerous structure excessively modified, the enamel pattern consisting of parallel transverse laminae (parallel: *Dinomyidae*); mandible with no sharply defined ridge for attachment of masseter lateralis; external form saltatorial.

South America; Miocene to Recent. Living genera: *Chinchilla, Lagostomus, Viscaccia.* Extinct genera: *Euphilus, Perimys, Pliolagostomus, Prolagostomus, Scotaëumys, Sphaeromys.*

### Family Abrocomidae

Like the *Chinchillidae* but cheekteeth with deep reentrant angles on both sides, and mandible with sharply defined ridge for attachment of masseter lateralis; external form not saltatorial.

*Abrocoma;* South America; Pliocene to Recent.

[10] The feet of *Neoreomys* are imperfectly known, but there appears to be nothing in the structure of the parts which have been described that indicates the presence of more than three digits in the hind foot.

MEDIALIS SERIES

Masseter medialis the chief agent in modifying form of outer side of mandible; a conspicuous horizontal ridge for the attachment of this muscle present on side of mandible slightly below alveolar level.

### Family CAVIIDAE

Posterior cheektooth both above and below without reduplication of elements, the general character of the toothrow normal.

The *Caviidae* of authors with *Hydrochoerus* and its allies removed; South America; Miocene to Recent. Extinct genera: *Anchimys, Neoprocavia, Orthomyctera, Palaeocavia, Phugatherium, Procardiotherium.*

### Family HYDROCHOERIDAE

Posterior cheektooth both above and below with conspicuous reduplication of elements, the general character of the toothrow thus rendered abnormal.

*Hydrochoerus* and its extinct allies *Plexochoerus, Prohydrochoerus* and *Protohydrochoerus;* perhaps *Cardiomys, Caviodon* (= *Diocartherium*) and *Cardiotherium* also; South America, Miocene to Recent; southeastern United States, Pleistocene.

## ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

GEOGRAPHY.—*Geography of the world's agriculture.* V. C. FINCH and O. E. BAKER, Office of Farm Management. Pp. 149, including 206 text figures and 2 inserted colored maps. "1917" [April, 1918].

This contribution from the Office of Farm Management is an elaboration of an article by the same authors in the 1916 Yearbook of the Department of Agriculture, and a sort of forerunner of the Atlas of American Agriculture now in preparation by the Office of Farm Management under the immediate direction of Mr. Baker.

Maps in black and white, with the acreage and production of all the more important crops of the world indicated by dots, occupy over half the space, and in addition there are many instructive graphs. The maps of the United States and Europe are naturally more detailed than those of other parts of the world, where statistics are not gathered so systematically. One of the colored maps shows land relief and the other mean annual precipitation for the whole world exclusive of the polar regions; and by comparing the crop maps with these many more or less striking correlations of crops with altitude and moisture can be made out. Our knowledge of soil conditions is as yet far too fragmentary to warrant the preparation of a soil map of the world, but numerous correlations between crops and soils are pointed out in the text.

It is impracticable to go further into details here, but this atlas, or album, probably brings out the salient features of the world's agriculture at the beginning of the great world war better than any other publication, and it will be an indispensable reference book for students of economic geography and all persons interested in the relation of geographic conditions to the distribution of crops and live stock throughout the world.

R. M. HARPER.

GEOLOGY.—*Possibilities for manganese ore on certain undeveloped tracts in Shenandoah Valley, Virginia.* D. F. HEWETT, G. W. STOSE, F. J. KATZ, and H. D. MISER. U. S. Geological Survey Bulletin 660-J. Pp. 26, with maps, and sections. 1918.

Most of the manganese deposits occur in banded clays that are believed to have been derived by weathering in place from the lower 200 feet of the Shady dolomite which rests on the Erwin quartzite. In most places the local structure of the adjacent rocks has determined the form of the deposits and in large measure their areal extent and their persistence below the surface. The tracts that are considered favorable for the occurrence of manganese or manganiferous iron ore are underlain by troughs of the upper beds of the Erwin quartzite, from the surface of which the products of decay of the overlying Shady dolomite have not been removed.

The manganese seems to have been originally widely disseminated as carbonate in the limestone and dolomite in the neighborhood of the deposits. It was dissolved as bicarbonate and transported along established channels of circulation to the places where the oxides are now found. The oxides were probably deposited when and where the solutions containing manganese bicarbonate met oxygen-bearing waters. According to the hypothesis structural troughs were the most favorable channels for circulation, and if suitable conditions for oxidation and deposition existed they should be the most favorable places for accumulation.

Six undeveloped tracts along the west front of the Blue Ridge are described in which prospecting with a view to the discovery of manganese deposits is recommended.

R. W. STONE.

GEOLOGY.—*Manganese at Butte, Montana.* J. T. PARDEE. U. S. Geol. Survey Bull. 690–E. Pp. 20. 1918.

Rhodochrosite, rhodonite, and manganese oxides are abundant at Butte. Rather curiously, manganese minerals are scarce in the veins that yield copper ore, but in a peripheral zone commonly known as the silver area, manganese minerals are plentiful. The width of the zone in which the veins are strongly manganiferous ranges from 1 to 2 miles approximately, being greatest toward the west.

About half of the manganiferous zone lies north of the copper area and east of the rhyolite. Though manganese is widely distributed in all parts of the zone, it appears to be relatively most abundant in the southwestern section. It occurs abundantly as deep as the workings

have gone, though it seems to be less plentiful in the deeper parts of the veins.

Owing to the absence of silica and to the ease with which the carbonate can be changed to an oxide, simple calcination being sufficient to drive off the carbon dioxide, and to the comparative difficulty experienced in decomposing the silicate, the rhodochrosite is by far the more valuable as a source of the metal. Fairly pure rhodochrosite occurs in several places.

A reserve of not more than 2600 tons, as estimated, contains 40 per cent or more manganese, and but little more than one-third of this amount runs less than 10 per cent silica. In addition fairly detailed estimates show totals of about 132,000 tons of material averaging 24 per cent manganese and 50 per cent silica and 270,000 tons averaging 11.5 per cent manganese and 73 per cent silica. Tests of the richer of these two grades so far reported by the mining companies, though not wholly satisfactory, by no means discourage the hope that it can be profitably concentrated.

R. W. STONE.

GEOLOGY.—*The coal fields of the United States. The coal fields of Ohio.* J. A. BOWNOCKER, State Geologist. *With a computation of the original coal content of the fields.* F. R. CLARK. U. S. Geol. Survey Prof. Paper 100–B. Pp. 62, with maps and sections. 1917.

A description of the occurrence, composition, and uses of Ohio coals, with a bibliography; includes also an estimate of the original coal content of the Ohio fields. The principal part of the tonnage is contained in seven coal beds. It is estimated that the total original tonnage of all beds in all counties was 87,638,000,000 short tons, and that after deducting the quantity mined and wasted in mining, there remains available 86,552,000,000 short tons.

R. W. STONE.

GEOLOGY.—*Geology and paleontology of the Raton Mesa and other regions in Colorado and New Mexico.* WILLIS T. LEE and F. H. KNOWLTON. U. S. Geol. Survey Prof. Paper 101. Pp. 450. 1917.

The principal conclusions arrived at in this report are as follows:

The coal-bearing rocks of the Raton Mesa region, which have formerly been referred to the Laramie, constitute two distinct formations, separated in time by a period of erosion.

The lower formation, to which the name Vermejo is here applied, contains a Montana flora. It is distinct from the Laramie flora of the Denver Basin, and proves that the Vermejo formation is older than Laramie, and that it is more closely related to the Mesaverde of western New Mexico than to any other formation yet examined.

The coal-bearing rocks of the Canon City field are correlated by lithology, stratigraphic position, and fossil plants with the Vermejo of the Raton Mesa region and are designated by the same name. The character of the invertebrates found in the Vermejo of the Canon City field in the midst of the plant-bearing beds suggests that this formation is approximately equivalent in age to the Fox Hills of the Denver Basin.

The upper formation of the Raton Mesa region, to which the name Raton is here applied, is Eocene in age and contains a flora distinct from that of the Laramie of the Denver Basin but similar to that of the post-Laramie formations of that basin and to that of the Eocene Wilcox group of the Gulf Coast.

The unconformity between the Vermejo and Raton formations represents a time interval comparable to that described as separating the Laramie from the Arapahoe of the Denver Basin. Separating, as it does, the youngest Cretaceous of the region from the oldest Eocene, it represents post-Cretaceous erosion and is correlated with the post-Laramie unconformity of the Denver Basin.

Lee's discussion of the geology of Raton Mesa is followed by Knowlton's description of the fossil flora of the Vermejo and Raton formations. The flora is abundantly figured and some of the illustrations are exceptionally large. That the age of the Vermejo formation is Cretaceous is established by its stratigraphic position, its invertebrate fossils, and especially by its plants, which correlate it with the Montana in the approximate position of the Mesaverde formation. The Vermejo is terminated by an unconformity, and so far as is at present known only 4 of the 108 Vermejo species pass over the unconformity and are found in the Raton formation.

The Raton formation is to be correlated with the Wilcox, and probably with the Midway formation of the Gulf region. The Tertiary age of the Midway and Wilcox formations is not questioned. On the basis of the plants the Raton formation is also correlated with the Arapahoe and the Denver formations of the Denver Basin; and the latter is now known to be correlated with, and in fact to be practically continuous with, the Dawson arkose. The conclusion is reached that all these formations are Tertiary (Eocene) in age.

R. W. STONE.

GEOLOGY.—*The Lake Clark-Central Kuskokwim region, Alaska.* PHILIP S. SMITH. U. S. Geol. Survey Bull. 655. Pp. 162, with maps and illustrations. 1917.

This report describes the areal geology of the Lake Clark-Central Kuskokwim region, Alaska. The region is in southwestern Alaska and extends from the Pacific Mountains to the central part of the Yukon Plateau province. The rocks are dominantly sedimentary strata of Mesozoic age, but some Paleozoic limestones are also exposed. Igneous rocks both of intrusive and effusive origin occur at a number of places and certain of them seem to be closely associated with deposits of commercial value, such as gold and quicksilver. Unconsolidated deposits are widespread and throughout much of the region mantle the underlying bedrock. These deposits are mainly of glacial and glacio-fluviatile origin, though lacustrine, fluviatile, and volcanic ash deposits occur also.

P. S. S.

GEOLOGY.—*The structural and ornamental stones of Minnesota.* OLIVER BOWLES. U. S Geol. Survey Bull. 663. Pp. 225, with maps and illustrations. 1918.

In this bulletin the history of the industry is summarized, the rocks of Minnesota and their constituent minerals are described, and an outline of the geologic history is given. A brief account of the properties essential to the usefulness of stones is followed by a general discussion of the crystalline rocks of Minnesota. Detailed descriptions of the quarries, of their products, mode of operation, equipment, ownership, and means of transportation, form the main body of the report. The stones quarried are granite, gabbro, diabase, limestone, marble, sandstone, and quartzite. As a guide for prospective operators undeveloped outcrops as well as quarries are described.

R. W. STONE.

GEOLOGY.—*A geologic reconnaissance of the Uinta Mountains, northern Utah, with special reference to phosphate.* ALFRED R. SCHULTZ. U. S. Geol. Survey Bull. 690–C. Pp. 64, with maps. 1918.

The rocks in the Uinta Mountain region range in age from pre-Cambrian to Quaternary, inclusive. The Park City formation, in which the phosphate deposits occur, and the formations immediately underlying and overlying it are described so that the phosphate-bearing beds and the rocks associated with them may be compared with the phosphate-bearing beds of other localities in the Rocky Mountain region.

The structure of the Uinta uplift, considered as a whole, is comparatively simple. On closer study, however, the long, narrow, flat-topped east-west fold which is here called the Uinta anticline is found to be much more complex and to consist of numerous secondary anticlines and synclines, some parallel to the main axis and others at right angles to it. There are also numerous low cross folds along the flanks of the major fold, expressed in undulations, local sags, and irregularities along both sides of the range. The anticlinal fold is further complicated by many normal faults and some thrust faults, both parallel and transverse to the strike of the beds. The major structural feature of the Uinta Mountains, however, consists of a huge east-west anticlinal arch approximately 100 miles long, and from 35 to 50 miles in width. This huge arch, which consists of rocks ranging in age from pre-Cambrian to Tertiary, separates the Green River Basin on the north from the Uinta Basin on the south.

The distribution of the phosphate beds and the Park City formation, which contains them and which is equivalent to the Phosphoria formation and the upper part of the Wells formation of eastern Idaho in the Bear Lake region, is shown by a map.

The analyses show considerable variation, but they indicate the presence of some high-grade rock that carries approximately the equivalent of 70 per cent of tricalcium phosphate.

No detailed work upon which to base a reliable estimate of tonnage has been done in this field. It is apparent, however, from the reconnaissance examination that a large amount of phosphate is present.

R. W. Stone.

GEOLOGY.—*The gold placers of the Tolovana district, Alaska.* J. B. Mertie, Jr. U. S. Geol. Survey Bull. 662–D. Pp. 221–277, with maps and illustrations. 1917.

The Tolovana district lies in the northwestern part of the Fairbanks quadrangle, in the headwater region of Tolovana River and Hess Creek. The report describes the gold placers of Livengood Creek and near-by streams and the geology and mineral resources of the surrounding territory, designated the Tolovana district. Much emphasis is placed on topographic anomalies in the form of extensive changes in drainage, and on Quaternary deposits and their history, all of which is intimately related to the distribution of the gold. The origin of the gold in its bedrock sources in the vicinity of Livengood Creek is related to the intrusion of siliceous igneous rocks, with the subsequent escape of mineralizing solutions therefrom.

The means and cost of obtaining supplies and the availability of wood, water, and game are mentioned.

R. W. STONE.

GEOLOGY.—*The geology and ore deposits of Ely, Nevada.* ARTHUR C. SPENCER. U. S. Geol. Survey Prof. Paper 96. Pp. 189. 1917.

The great bulk of the rocks of the Ely quadrangle are limestones, quartzites, and shales, which range in age from Ordovician to Carboniferous and which have an aggregate thickness of more than 9000 feet. The sedimentary rocks have been classed under eight formations. They have been greatly disturbed by folding and especially by faulting, so that their areal distribution is very irregular. The six uppermost of the eight formations have been invaded in one place or another by masses of monzonite porphyry.

The igneous rocks of the district include an older set of monzonite porphyry intrusions and a younger set of tuffs, obsidians, and rhyolites. The monzonitic rocks are of particular interest because the genesis of the metallic ores of the district is closely connected with their geologic history. The conclusion is presented that all the coarse-grained intrusive rocks are to be referred to a single epoch of igneous activity, and it is shown that present differences in composition are due in the main to the more or less intense metamorphism which in many places the rocks have suffered.

Two kinds of metamorphism are distinguished. Under igneous metamorphism are included all those alterations that attended or followed the invasion of the sedimentary formations by the magma that eventually crystallized as monzonite porphyry. These alterations have affected the invaded limestones and shales and also the igneous rocks themselves. To this metamorphism is to be attributed the formation of the primary metalliferous deposits of the district. The second kind—atmospheric metamorphism—includes weathering, or decomposition and leaching by oxidizing surface waters, and cementation, or changes involving the deposition of material taken into solution during the process of weathering.

The enriched copper ores of the district have been formed as a result of atmospheric metamorphism. By considering the amount of oxygen that water can absorb by contact with the air under atmospheric pressure at 7000 feet elevation and at the present mean annual temperature of the region, it is found that, even if precipitation in the past has been 25 per cent greater than at present, and that as much as 60 per cent of the rainfall could have penetrated to the ore body, the oxygen re-

quired to oxidize 500 feet of ore like that now existing would require the contributions of rainfall during a period longer than physicists and geologists are willing to allow for the entire age of the earth. It is thought, therefore, that a large part of the oxygen must have been derived from air that circulated through the oxidized capping.

A theoretical discussion of the chemical reactions involved in the alterations of the rocks and in the deposition of metallic sulphides in them is presented. The conclusion is reached that if the solutions were originally acidic the metallic minerals were probably deposited only after an alkaline or neutral condition had been attained.

R. W. STONE.

TECHNOLOGY.—*Materials for the household.* Bur. Stand. Circ. No. 70. Pp. 259. Dec. 5, 1917.

This circular describes the more common materials used by the household, comprising paint materials, cement, clay products, lime, plasters and stucco, wood, metals, bituminous roofing, inks and dyes, adhesives, paper, textiles, rubber, leather, cleansers and preservatives, fuels, illuminants, and lubricants, and concludes with a chapter on quantity in the purchasing of materials. Each title is treated under the general heads of composition and definition, sources, properties, uses, tests, preservation, hints as to selection and use, and references.

TECHNOLOGY.—*Gas mantle lighting conditions in ten large cities in the United States.* R. S. MCBRIDE and C. E. REINICKER. Bur. Stand. Tech. Paper No. 99. Pp. 37. October 29, 1917.

From a careful inspection of about 4500 gas mantle lamps in service in ten cities, a summary of the condition of mantles, glassware, pilot light, and other particulars was made in order to determine to what extent the customer benefited through periodic maintenance service.

By these observations it is found that a lamp not on regular maintenance is likely to be defective five and one-half times as frequently as a lamp which is regularly maintained. Also it is shown that on the average 1 in 3 of the lamps on regular maintenance was not in good condition whereas the defects noticed in the lamps not so maintained average more than one for every lamp.

The principal defects in maintenance systems were also investigated and one satisfactory system of estimating the expenses for maintenance work together with a set of unit costs is presented, based upon the analysis of the operation of ten gas companies. A suggested table of costs for each type of unit is given. C. E. R.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## WASHINGTON ACADEMY OF SCIENCES

The Board of Managers met on June 8, 1918. The President was authorized to appoint Associate Editors for the JOURNAL, on the recommendation of the Board of Editors; the Associate Editors to be selected so as to represent informally the societies that publish proceedings in the JOURNAL. The following Associate Editors have been appointed: J. R. SWANTON, Anthropological Society; N. HOLLISTER, Biological Society; J. B. NORTON, Botanical Society; R. B. SOSMAN, Chemical Society; SIDNEY PAIGE, Geological Society; F. B. SILSBEE, Philosophical Society.

ROBERT B. SOSMAN, *Corresponding Secretary.*

## BOTANICAL SOCIETY OF WASHINGTON

The 129th regular meeting of the Society was held at the Cosmos Club at 8 p.m., Tuesday, May 7, 1918; 31 members and 3 guests present. Prof. A. S. HITCHCOCK presided. The following scientific program was given.

WILLIAM A. DAYTON: *Collecting data on National Forest range plants.* For nine years past the Forest Service has conducted a study of the distribution, natural habits, and economic importance of its range flora. Approximately 35,000 plant specimens, representing about 4,800 species, have been collected on National Forests and Purchase Areas. Ecological and economic data have been furnished by the collectors of most of these specimens, and this material has been supplemented by much detailed data procured by grazing experts of the Service. The specimens have been identified by experts of the Bureau of Plant Industry. Economic notes are compiled in the Washington office and distributed among Forest officers. These data have application to many phases of range-management, e.g., intensive range-utilization especially with a view to minimum interference with the requirements of the important forage plants, and the utilization of each type at the time and by the class of stock to which it is best adapted; detection, eradication, fencing, etc. of poisonous-plant areas; natural range reseeding; studies in carrying capacity, plant indicators, plant succession, artificial reseeding, etc.

W. W. EGGLESTON: *Nathaniel Jarvis Wyeth and his influence on western botany, with a sketch of his return trip from Oregon in 1833.* Capt. N. J. Wyeth was born in Cambridge, Massachusetts, in 1802. His

father was a Harvard graduate. Captain Wyeth received a business training, was one of the pioneers in the ice business, and an inventor of ice-cutting tools. Brought up in Cambridge, he seems to have taken advantage of his environment, as his letters and journals evidence. His interest in nature was fostered through friendship with Professor Thomas Nuttall of the Harvard Botanic Garden.

Through propaganda for the American colonization of Oregon, Wyeth's patriotic enthusiasm became so aroused that he joined the movement, but disagreeing with the leadership he organized the Pacific Trading Company, which started for Oregon in 1832 and after many discouragements reached Fort Vancouver, Washington, and disbanded.

The following spring Captain Wyeth accompanied the Hudson Bay Brigade to Camas Creek, Idaho, returning home with the Rocky Mountain Fur Company Brigade down the Yellowstone and the Missouri. On this spring trip Wyeth collected many new plants, from which Thomas Nuttall described two genera and fifty-four species. Captain Wyeth acquired such an interest in the country that he immediately planned a larger expedition. His friend Nuttall was induced to join. A stock company, the Columbia River Fishing and Trading Company was organized and an expedition of seventy men set out in the spring of 1834.

Financially this company failed and Wyeth closed the business, returning home in 1836. However, Captain Wyeth's second expedition took the first permanent American settlers to Oregon and blazed the trail for the great exodus to Oregon ten years later. As the result of this expedition J. K. Townsend collected and described many birds and animals. Nuttall described about eighty genera and seven hundred and fifty species of American plants.

V. K. CHESNUT: *Papain from Carica Papaya grown in Florida.* Genuine papain of good quality is so rare a product in commerce that the trade, and even most chemists, have been unable to learn its eminent worth as a protein digestant, especially from the manufacturing standpoint. Inability to control the product was thought to be due to a lack of knowledge of the ferment as well as to the need of a method of assay which would exclude pepsin and other enzymes which have been, or may be, used as adulterants. Forty-eight samples representing the latex from every variety and condition of fruit available at the Foreign Seed and Plant Introduction Field Station at Miami were collected by the author and twenty other genuine samples were secured from Honolulu and elsewhere. These were subjected to extended investigation and it was found that the optimal H- ion concentration and field of activity were identical in the case of all the specimens. A method of examination was finally arrived at which enabled the author not only to determine the comparative strength of a commercial sample, but at the same time, to detect the presence of pepsin or other enzymic adulterants. Much of the value of the latex depends upon the stage of ripeness of the fruit and especially the methods used for drying and conservation. Since only 10 mg. are required for an assay, it is now possible for an investigator to study the fruit with a view toward the selection of the varieties best suited for the

yield of papain of high quality. The product from Florida was found equal to that from Honolulu and very greatly superior to any found on the market.

H. N. VINALL, *Corresponding Secretary.*

## ENTOMOLOGICAL SOCIETY OF WASHINGTON

The 314th meeting of the Society was held at the Cosmos Club, June 6, 1918, with 24 members and one visitor in attendance. President E. R. SASSCER presided.

The following were elected to membership: Lieut. L. H. DUNN, of the Army Medical School; Mr. J. E. GRAF, Mr. E. H. DURHAM, and Mr. G. F. MOZNETTE, of the Bureau of Entomology.

The regular program was as follows:

C. H. POPENOE: *Eradication and control of the sweet potato weevil.* This preliminary statement of the work being done for the eradication of this imported pest of sweet potatoes was not intended for publication. Mr. Popenoe gave a very interesting account of the habits, distribution, and food plants of the insect, and extent of damage caused by the pest (*Cylas formicarius* Fabr.)

C. A. MOSIER and T. E. SNYDER: *Notes on gadflies in the Florida Everglades.* Read by title.

J. R. MALLOCH: *Genus* Cnemedon *Egger in North America* (*Dipt.*). Read by title.

Lieut. L. H. DUNN: *A new mosquito* (Aedes whitmorei) *from Colombia.*

A. B. GAHAN, *Recording Secretary.*

## SCIENTIFIC NOTES AND NEWS

The solar eclipse of June 8, 1918, was viewed at Baker, Oregon, by a party from the Naval Observatory consisting of Astronomer J. C. HAMMOND, Assistant Astronomer GEORGE H. PETERS, Assistant C. C. WILEY, and Assistant W. A. CONRAD, together with the following invited scientists: Professors S. A. MITCHELL and L. G. HOXTON, of the University of Virginia, Dr. P. W. MERRILL, of the Bureau of Standards, Dr. MARY MURRAY HOPKINS and Miss HARRIET BIGELOW, of Smith College, Mr. EDWARD D. ADAMS amd Mr. KEMPTON ADAMS, of New York City.

Assistant Astronomer H. R. MORGAN and Assistant W. M. HAMILTON, of the Observatory, made observations at Denver, Colorado.

Special measurements were made by observers from the Weather Bureau during the solar eclipse of June 8, 1918. At Goldendale, Washington, were installed a Smithsonian pyranometer for measuring the intensity of both the direct solar radiation and the diffuse sky-radiation, and a pyrgeometer for measuring the intensity of the outgoing radiation. A program of meteorological observations, arranged by Professor H. H. KIMBALL and Mr. S. P. FERGUSSON, and including atmospheric pressure, temperature of the air, direction of the wind, clouds and shadow-bands, was carried out at about fifty-five stations, nearly all of which were west of the Mississippi and within the belt where the sun was 90 per cent eclipsed.

The various parties sent out by the Carnegie Department of Terrestrial Magnetism and the United States Coast and Geodetic Survey, have all reported securing successful series of magnetic observations during the time of the total solar eclipse of June 8. Magnetic observations were made by the Coast and Geodetic Survey at Green River, Wyo., Mena, Ark., and Orlando, Fla. In addition data will be obtained from the various magnetic observatories of the Coast and Geodetic Survey. The stations at which magnetic observations were made by the observers of the Department of Terrestrial Magnetism, were: Goldendale, Wash.; Corono, Colo., at an altitude of 12,000 feet; Moraine Lake, Colo.; Lakin, Kans.; Brewton, Ala.; and Washington, D. C. At Lakin, furthermore, and at Washington, D. C., atmospheric-electric observations were made. Reports on the results obtained will be published in the September issue of the journal *Terrestrial Magnetism and Atmospheric Electricity*. Data will likewise be furnished by the Canadian magnetic observatories and by various universities.

Superintendents of the experiment stations of the Bureau of Mines met in Washington on May 13–16, 1918. Those in attendance were: VAN H. MANNING, Director; L. H. DUSCHAK, Berkeley, Cal.; E. A. HOLBROOK, Urbana, Ill.; J. O. LEWIS, Bartlesville, Okla.; D. A. LYON, Washington; R. B. MOORE, Golden, Col; F. G. MOSES, Salt Lake City, Utah; EDMUND NEWTON, Minneapolis, Minn.; R. T. STULL, Columbus, Ohio; C. E. VAN BARNEVELD, Tucson, Ariz.; THOMAS VARLEY, Seattle, Wash.; A. E. WELLS, Salt Lake City, Utah.

A section on medicines and medical supplies has been added to the War Industries Board, with Lieut.-Col. F. F. SIMPSON as chief of the section. It will be closely coordinated with that section of the Chemical Division which deals with fine chemicals.

The authorized quota for the Chemical Service Section of the National Army has been increased to a total of over 1300.

The Bureau of Yards and Docks, Navy Department, has awarded a contract for the construction of a mine laboratory, to cost $73,000, at the Washington Navy Yard.

The Magnetic Survey Vessel, *Carnegie*, arrived safely at her home port, Washington, D. C., on June 10, where she will be put out of commission probably during the period of the war. During her cruise from Buenos Aires, Argentina, round the Horn to Valparaiso, Chile, Callao, Peru, thence through the Panama Canal to Newport News, she was in command of Dr. N. W. EDMONDS; the other members of the scientific staff aboard were: Messrs. A. D. Power, BRADLEY JONES, L. L. TANGUY, J. M. MCFADDEN, and WALTER E. SCOTT. On Sunday, June 23, she was visited by a number of the scientific men of Washington.

Prof. E. C. FRANKLIN, of Stanford University, California, Mr. WM. HOSKINS, of Chicago, Dr. WM. H. NICHOLS, of the General Chemical Company, Prof. T. W. RICHARDS, of Harvard University, Prof. H. P. TALBOT, of the Massachusetts Institute of Technology, and Prof. S. P. VENABLE, of the University of North Carolina, were in Washington in May in attendance upon the opening conference between the national advisory committee of the Experiment Station of the Bureau of Mines, and the members of the Bureau in charge of the work of the Experiment Station.

Maj. JAMES W. BAGLEY, of the Engineers Corps, National Army, formerly of the Geological Survey, has been assigned to duty at the office of the Chief of Engineers in Washington.

Mr. WILLIAM T. BRIGHAM, director of the Bishop Museum of Honolulu, Hawaii, was in Washington in June, in conference with scientists of various government bureaus.

Mr. E. J. CASSELMAN, formerly engineer of tests of the Washington Steel and Ordnance Company, is assistant chemist with the Hygienic Laboratory for the Public Health Service.

Professor A. D. COLE, professor of physics at Ohio State University, is in Washington for the summer, engaged in research work at the Bureau of Standards.

Professor M. F. COOLBOUGH, of the department of chemistry, Colorado School of Mines, is in Washington on leave of absence and is engaged in war work at the Bureau of Mines.

Dr. ARTHUR L. DAY, director of the Geophysical Laboratory, received the honorary degree of Doctor of Science from Princeton University on June 15, 1918.

Professor FRED DUNLAP, of the University of Missouri, formerly with the forest products section of the U. S. Forest Service, was in Washington in June arranging to do special work for the Service in the Mississippi Valley.

Mr. ROY Y. FERNER, associate physicist of the Bureau of Standards, resigned from the Bureau in June, and is now connected with the instrument purchasing section of the Shipping Board, in Philadelphia.

Professor E. C. FRANKLIN, of the department of chemistry, Leland Stanford Junior University, and Professor WILLIAM S. FRANKLIN, of the department of physics, Massachusetts Institute of Technology, are in Washington for the summer, engaged in research work at the Bureau of Standards.

Mr. OWEN B. FRENCH, formerly Assistant in the U. S. Coast and Geodetic Survey, has gone to Peking, China, to take the chair of Geodesy and Practical Astronomy in the Government Institute of Military Surveying. He sailed from San Francisco on March 16 and arrived in Peking on April 13, 1918, having spent a few days in Japan. He expects to remain in Peking for somewhat less than two years and will then return to Washington.

Dr. GEORGE GAUMER, botanist and ethnologist, of Yucatan, Mexico, was in Washington in May in conference with scientists of the National Museum.

Mr. WILLIAM J. HAMMER, consulting physicist and electrical engineer, of New York, has been commissioned a major in the National Army, and is assigned to duty in Washington with the newly organized Inventions Section of the General Staff.

Mr. JOHN B. HENDERSON is at Barbados, British West Indies, with Prof. C. C. NUTTING'S zoological expedition from the University of Iowa.

Mr. NEIL M. JUDD, assistant curator of anthropology in the National Museum, has recently returned from explorations of the House Rock valley and the Pahreah and Wahalla plateaus, on the north rim of the Grand Canyon in northern Arizona. Several cliff dwellings and ruins were discovered. Since his return to Washington, Mr. Judd has enlisted in the aviation section of the Signal Corps.

Prof L. KOMATSU, of the University of Kyoto, and Prof. K. KITAWAKI and Dr. SHIBUSAWA, of Tokyo, visited Washington in June.

Mr. E. S. LARSEN, JR., of the Geological Survey, has been examining the tungsten resources of the Western States.

Dr. H. M. LOOMIS, formerly of the Bureau of Chemistry, Department of Agriculture, has been made chief inspector, for the Food Administration, of the sardine canneries of Maine and Massachusetts.

Mr. FRANK N. MEYER, of the office of foreign seed and plant introduction of the Bureau of Plant Industry, and agricultural explorer for the Department of Agriculture, met an accidental death in China on or about June 2, 1918, according to word received in Washington on June 18. He disappeared from a steamer on the Yangtze-Kiang and his body was discovered a week later. Mr. Meyer had been an explorer in China, Siberia, and Turkestan for about ten years past. He was a member of the Botanical Society of Washington, and author of many contributions to botanical and horticultural science, including the discovery of the origin of the chestnut-bark disease and the blight-resistant species of chestnut in China.

Prof. SAMUEL P. MULLIKEN, professor of organic chemistry at the Massachusetts Institute of Technology, has been commissioned a major in the Chemical Service Section, National Army.

Dr. JAMES F. NORRIS, of the Bureau of Mines Experiment Station, and formerly professor of applied chemistry at the Massachusetts Institute of Technology, has been commissioned a lieutenant-colonel and is assigned to the embassy in London.

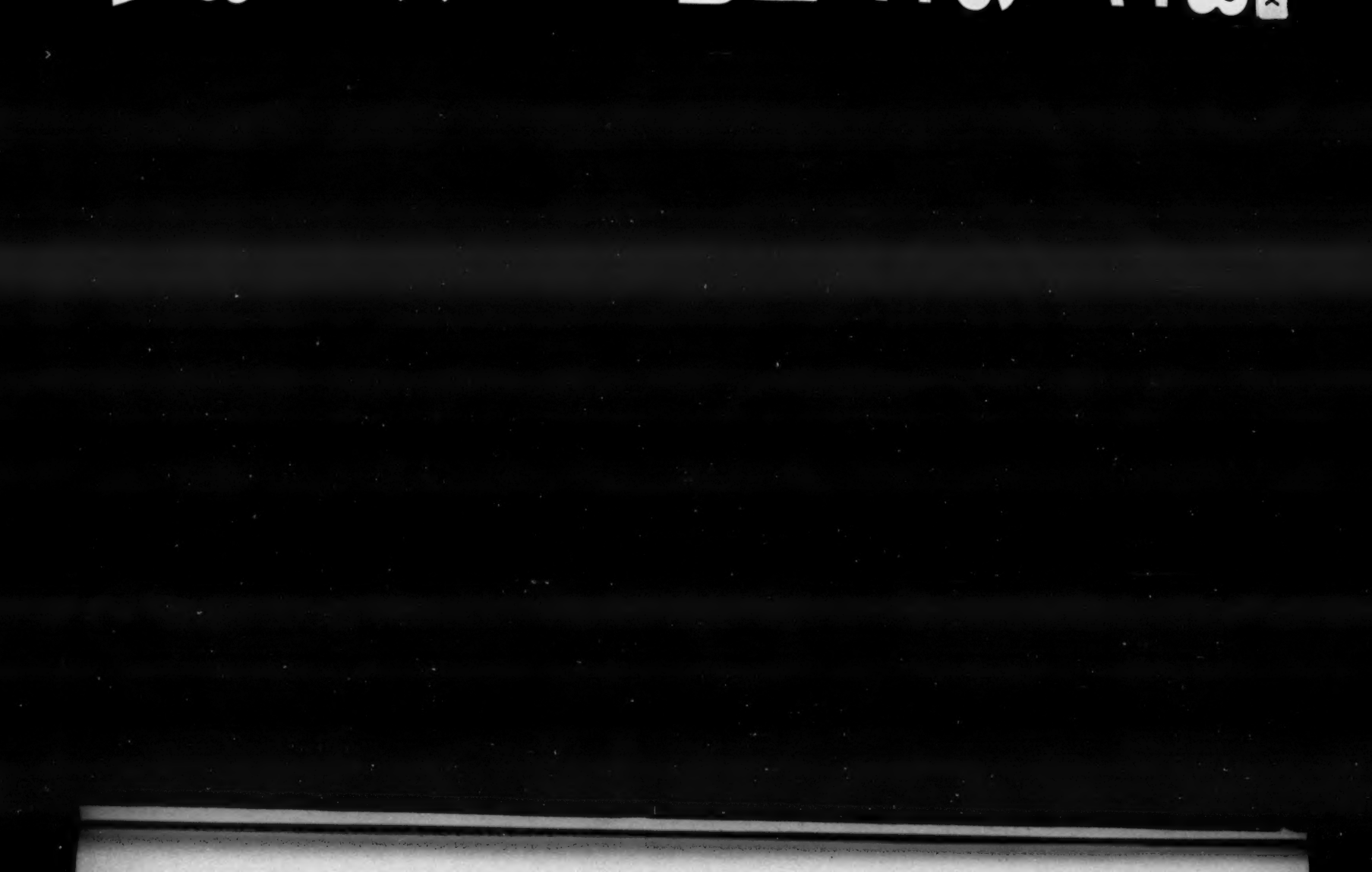
Dr. WILLIAM BATTLE PHILLIPS, consulting mining geologist, of Houston, Texas, and a nonresident member of the ACADEMY, died on June 7, 1918, at the age of 61. Dr. Phillips had been connected during his lifetime with a wide variety of scientific and technical interests, having been on the faculties of the University of North Carolina and the University of Alabama; chemist of the Tennessee Coal and Iron Company; a mem-

ber of the staff of several technical journals; director of the University of Texas Mining Survey; and president of the Colorado School of Mines. He was the author of nearly three hundred papers and reports on scientific and technical subjects.

Prof. C. A. SKINNER, professor of physics at the University of Nebraska, has been on leave of absence since early this year, and is engaged in research at the Bureau of Standards.

Dr. WILLIAM S. THAYER of Baltimore, a nonresident member of the ACADEMY, is in France as Medical Director with the U. S. Expeditionary Forces. Dr. Thayer returned a few months ago from Russia with the American Red Cross Mission.

Dr. HARRY W. TYLER, professor of mathematics at the Massachusetts Institute of Technology, is in Washington for the summer as a special agent in the federal employment service.

Dr. RALPH G. VAN NAME, of the department of chemistry, Yale University, came to Washington in June for war research at the American University Experiment Station of the Bureau of Mines.

Professor E. W. WASHBURN, of the department of ceramics, University of Illinois, is in Washington for the summer, engaged in chemical work for the National Research Council.